



Degenerative Injury and Acute Trauma Lead to Rotator Cuff Tear: How can we Judge the Relationship Between Acute Trauma and Disease?

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Abstract

Degenerative injury (own disease) and acute trauma are the two most common causes of rotator cuff tears (RCTs). It is always difficult to judge whether an RCT is caused by the former, the latter or the combination of both when the two factors coexist in the clinical appraisal of forensic medicine. To solve this problem, this paper reviews the literature from four aspects: the anatomical structure of the rotator cuff, the injury mechanism of the RCT, medical imaging and forensic clinical identification. We hope to provide a reliable forensic path for determining the relationship between acute trauma and one's own disease through a discussion of the following content.

Key ideas

- The signs of accompanying injury on MRI and the magnitude and form of acute trauma can be used to analyze whether acute trauma leads to RCT.
- Depending on X-ray or CT and MRI, the factors of own disease can be analyzed to determine the degree of the disease.
- The above two parts form clear appraisal results for court judgment.

Keywords: Rotator Cuff Tear; Medical Imaging; Forensic Medicine

Abbreviations

RCTs: Rotator Cuff Tears; AI: Acromial Index; LAA: Lateral Acromion Angle; CSA: Critical Shoulder Angle AHD: Acromial-Humeral Distance; AGA: Acromial Glenoid Angle; GI: Glenoid Inclination; FI: Fatty Infiltration; OG: Occupation Grade.

Introduction

RCT can be divided into acute traumatic tears and degenerative tears (own disease) depending on the cause of the damage [1-4]. Cases in which two factors coexist often appear in forensic identification. However, the lack

of understanding of objective identification factors often leads many forensic appraisers to face trouble, and the final appraisal opinions arouse the doubts of the parties. Therefore, to provide a reliable practice basis for the judgment of the injury relationship of RCTs, this paper combines the results of previous clinical research to analyze the influencing factors of RCTs from the perspective of forensic medicine.

Anatomy of the Rotator Cuff

The tendon complex formed by the terminal tendons of the infraspinatus, supraspinatus, teres minor, and subscapularis muscles is called the rotator cuff. The rotator



cuff serves as a bearing to maintain the stability of the miciohumeral joint and prevent joint dislocation during joint movement.

The tendons constituting the rotator cuff arise from the scapula, with the subscapularis ending at the lesser tuberosity of the humerus and the infraspinatus, supraspinatus, and teres minor ending at the greater tuberosity of the humerus. In addition, because the branches of the superior and inferior scapular arteries and the branches of the pronator arteries cross each other near the insertion of the greater tuberosity of the humerus of the supraspinatus and infraspinatus muscles, the blood supply of the corresponding parts is significantly reduced, which Codman EA, et al. [5] called this area “the risk area of poor blood supply”. In clinical practice, supraspinatus muscle tears are prone to be accompanied by partial infraspinatus muscle fiber bundle rupture, accounting for approximately 90% of RCTs [6].

Mechanism of Rotator Cuff Tear

Degenerative Tears (Own Disease): According to Codman’s theory of endogenetic tendinosis [7], with aging, muscle cells begin to degenerate and become necrotic, and some fibers rupture until RCT, which is a progressive

pathological change. Using ultrasound to analyze 90 patients with rotator cuff tears aged 30--90 years, Milgrom C, et al. [8] reported that the incidence of RCT significantly increased in patients over 50 years of age, and the incidence of RCT was greater than 50% in patients over 70 years of age and up to 80% in patients over 80 years of age.

Neer’s theory of external impingement [9]: The subacromial bursa, supraspinatus and infraspinatus muscles are repeatedly rubbed and impacted in the subacromial space when the shoulder is lifted, which results in a series of pathological changes, such as local inflammation and injury. This phenomenon is called impingement syndrome. Depending on the location of impingement, it can be divided into subacromial impingement, subcoracoid impingement and intrarotator cuff impingement. In clinical practice, impingement syndrome is usually referred to as subacromial impingement. Since this theory was proposed, the relationship between the shape of the acromion and rotator cuff tear has attracted increasing attention. In 1986, Bigliani LU, et al. [10] classified the data, as shown in Figure 1A previous study revealed that 95% of RCTs involved subacromial impingement, especially type III acromions [11].

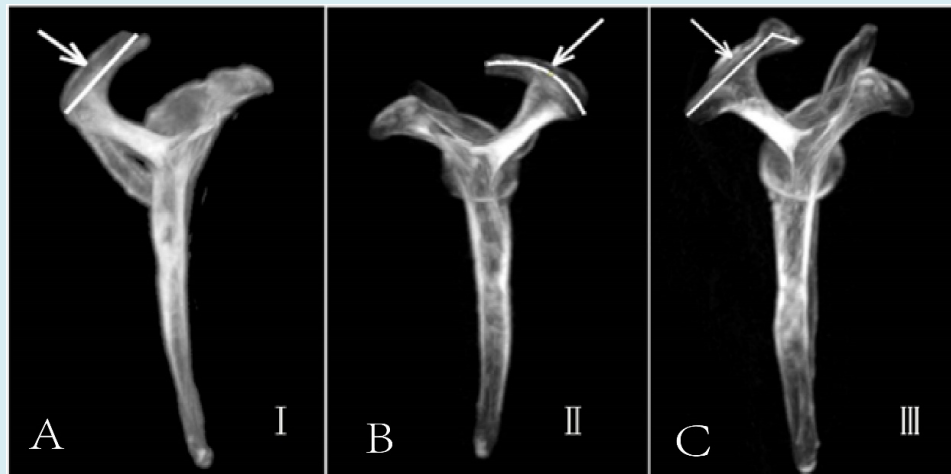


Figure 1: Acromion Classification (A-C). The MIP Reconstructed Images After The CT Scan: A: Type I Acromial Flat Type; B: Type II Acromial Arc; C: Type III Acromial Hook

Acute Trauma Tears (Trauma Factor)

According to the magnitude of external force and injury time, trauma can be divided into acute trauma and repeated minor trauma (chronic subacromial impingement). The latter is a disease factor and is the cause of most RCTs. In contrast, RCTs and investigations of the normal bone structure of the shoulder caused by acute trauma are rare, and injury factors in combination with the mode of force

action during trauma need to be analyzed [12]. For example, if the external force acts on the top of the shoulder joint, the acromion and proximal humerus will be affected by the downward impact force, leading to bone injury and rotator cuff tear in the corresponding parts. Pulling the upper arm downward, the force acts on the greater/lesser tuberosity of the humerus, causing the attachment point of the rotator cuff to tear and also leading to the medial and inferior dislocation of the shoulder joint. When the upper arm is subjected to

extreme abduction and external rotation, the reduction of the subacromial distance leads to the tear of the supraspinatus muscle, and the bone morphology generally does not change significantly.

Medical Imaging Examination

X-ray and CT The anteroposterior radiographs and Y-view radiographs of the supraspinatus outlet, or MPR and VRT reconstruction images of CT scan are often used to evaluate the changes of the shoulder bone structure of degenerative-RCT. Evaluation indicators include Acromial index (AI), Lateral acromion angle (LAA), Critical shoulder angle (CSA), and Acromial-humeral distance (AHD), Acromial glenoid angle (AGA), Glenoid inclination (GI), and other indicators.

AI is the ratio of the distance from the outermost edge of the acromion and the outermost edge of the humeral head to the glenoid tangent line, respectively, on the anteroposterior radiograph, Figure 2A. AI is used to evaluate the lateral

extension of the acromion. The risk of rotator cuff tear increases with the increase of AI. The reason may be that the increase of the lateral extension of the acromion will increase the force of the deltoid muscle in the vertical direction, which will lead to the increase of the risk of RCT.

Pandey V, et al. [11] found that an increase in AI indicates the presence of a full-thickness RCT. However, in the actual measurement, AI is greatly affected by the relative position of the humeral head and acromion, and standardization of the X-ray projection position is particularly important for ensuring measurement accuracy.

LAA refers to the angle between the tangent line of the inferior surface of the acromion and the glenoid on the anteroposterior X-ray (Figure 2B). Banas MP, et al [13]. reported that the average value of this angle was approximately 78°, and the incidence of RCT tended to increase as the LAA angle decreased.

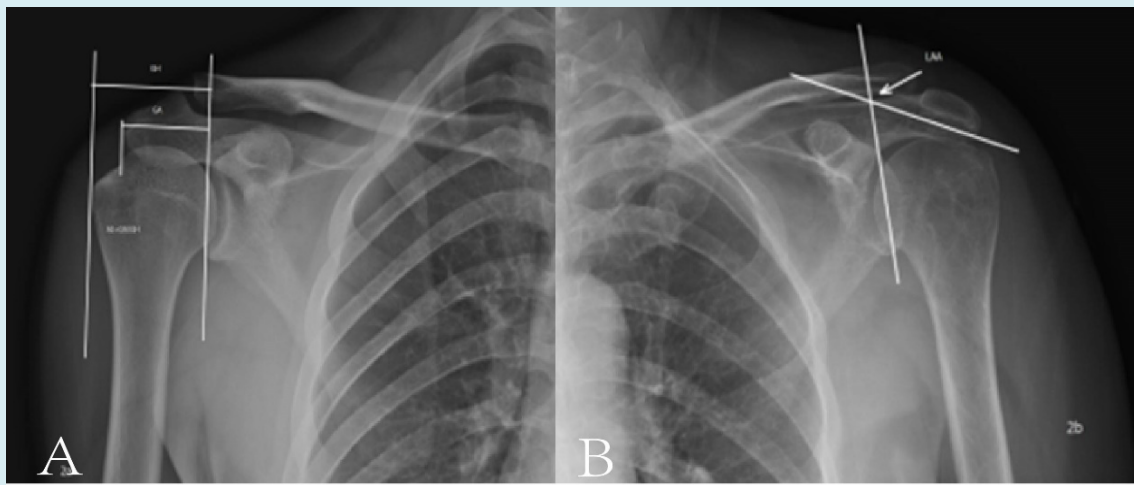


Figure 2: Schematic Diagram of AI and LAA (A, B). A: Distance from the Outermost Border of the Acromion of the GA to the Glenoid Tangent; Distance from the Most Lateral Margin of the Humeral Head to the Glenoid Tangent, $AI=GA/GH$; B: LAA Measurements (Arrows).

The CSA is the angle between the line connecting the lowest point of the glenoid to the outermost border of the acromion and the glenoid tangent (Figure 3A). This parameter takes into account the influence of both the glenoid tilt angle and lateral acromion extension. According to the literature, a $CSA > 35^\circ$ indicates a rotator cuff tear [14]. In addition, other studies have reported that the CSA angle of patients with complete rotator cuff tears and arthritis tends to significantly increase [15], and analysis suggests that the extra load of the supraspinatus muscle to maintain the stability of the shoulder joint may be caused by the extra load of the supraspinatus muscle. Chalmers PN, et al. [16] reported that the CSA angle was not correlated with the

severity of rotator cuff tears or disease progression.

AHD refers to the vertical distance from the lowest point of the lower acromion to the humeral head (Figure 3B), which is affected by the upward displacement of the acromion and the humeral head at the same time and is an effective indicator for evaluating the RCT and the degree of tear. The normal range of AHD is 7–13 mm, with less than 7 mm indicating a rotator cuff tear. Nove-Josserand L, et al. [17] reported that reduced AHD was associated with tears of multiple tendons, such as the supraspinatus and infraspinatus, rather than merely suggesting supraspinatus tears.

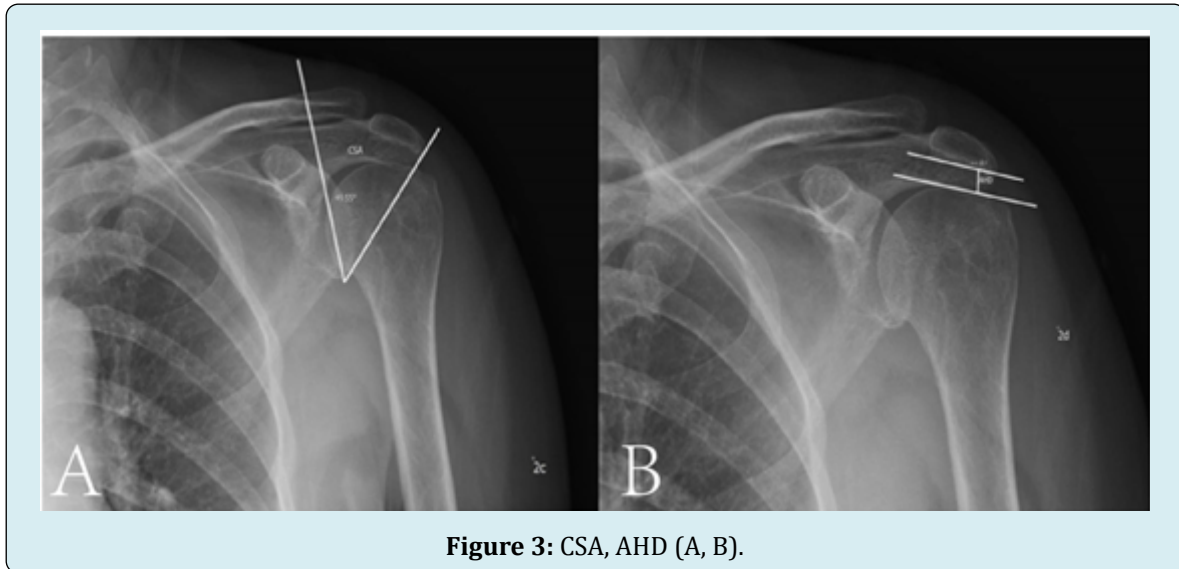


Figure 3: CSA, AHD (A, B).

The AGA refers to the angle formed by the connection between the highest point of the glenoid and the midpoint of the connection between the lowest point and the inferior edge of the acromion [18] (Figure 4A). AGA is a predictive indicator for the diagnosis of RCT and shoulder arthritis and is strongly correlated with the CSA, AHD, and AI.

The angle between the bottom margin of the superior fossa of the GI finger and the connection between the highest

point and the lowest point of the glenoid is shown in Fig. 4B. This parameter has little individual variation and is also an effective indicator. Beeler S, et al. [15] reported that the GI angle of full-thickness rotator cuff tears was approximately 98.6° greater than 91.0° in patients without rotator cuff tears and that the angle was the largest in patients with arthritis, suggesting that the GI angle may be related to the development of shoulder joint diseases.

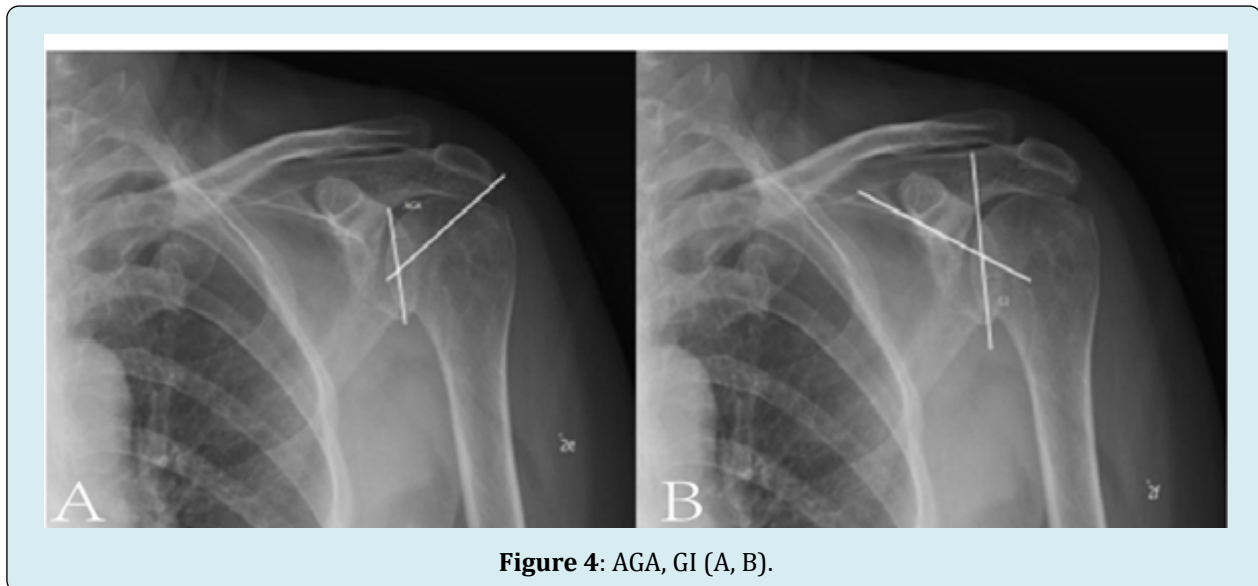


Figure 4: AGA, GI (A, B).

MRI can be used not only to diagnose RCT and tear types but also to evaluate fatty infiltration and atrophy of the tendon. Studies have shown that the sensitivity and specificity of MRI in the diagnosis of RCT tears can reach more than 90% [19]. In forensic expertise, MRI is also the main reference basis for determining the relationship of RCTs.

Rotator cuff fatty infiltration (FI) and occupation grade (OG) are common causes of degenerative RCTs [20]. Fuchs B, et al. [21] first used sagittal T1WI images of MR images to classify the degree of fatty infiltration. In addition, the occupation grade (OG) by Thomazeau H, et al. [22], the tangent sign (TS) by Zanetti M, et al. [23], and the grading system of rotator cuff atrophy by Warner JJ, et al. [24] can

also be used to quantitatively measure the degree of rotator cuff atrophy. The former two methods are most commonly used at present.

OG refers to the surface area of the supraspinatus muscle over the surface area of the supraspinatus fossa on oblique

sagittal T1WI images. The tangent sign refers to the degree to which the line between the superior edge of the scapula and the supraspinatus muscle jumps on the oblique sagittal plane of the MR image (Table 1 and Figure 5). The above study revealed that the more severe the degree of FI and OG was, the more likely the RCT was.

Types	Extent
Fuchs system FI grading	
Mild	No fat or little fat
Medium	More muscle than fat
Severe	Equal amounts of fat and muscle or more fat than muscle
Thomazeau system OG grading	
I	0.6~1.0
II	0.4~0.6
III	<0.4
Warner System TS rating	
I	Normal
II	Medium
III	Heavy
IV	Severe

Table 1: Fatty Infiltration and Tendon Atrophy.

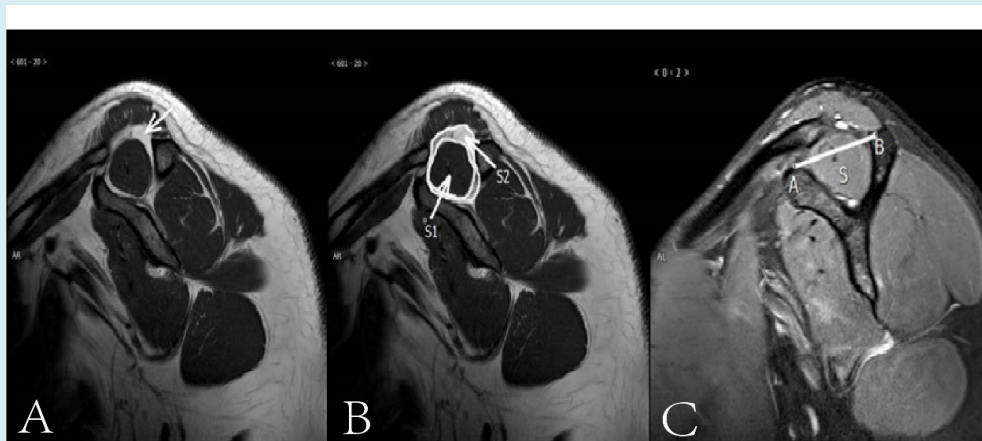


Figure 5: A: Oblique Sagittal T1WI Image, White Signal Represents Adipose Tissue (Arrow) (Fuchs Grade); B: Oblique Sagittal T1WI Image, S1 for Supraspinatus Muscle, S2 for Fat +S1, S1/S2=OG, (Thomazeau Classification); C: Oblique Sagittal Fat Suppression T2WI Image, Line Segment AB is the Connection Between the Superior Edge of the Two Ends of the Scapula, S Represents the Supraspinatus Muscle, S Above AB Is I°, Near AB Is II°, Slightly Below AB Is III°, and A Little Residual S Is IV° (Warner Classification).

Forensic Clinical Identification

As mentioned above, we need to judge the relationship between acute trauma and one's own disease, especially

in the case of RCTs involving acute trauma without serious shoulder fracture. Accurately judging the degree of participation of each factor is related to the compensation of the victims and the fairness of the judicial trial. According

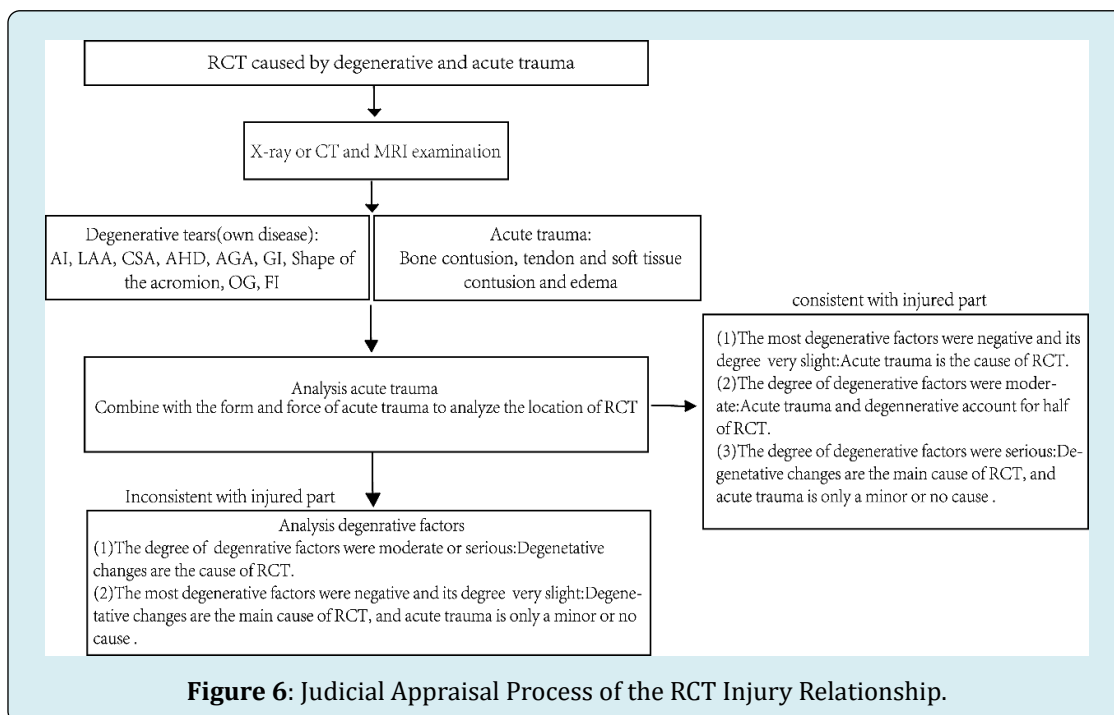
to forensic practice, when the relationship is judged, the following principles should be followed.

First, the traumatic factor is analyzed. The process and mode of trauma, especially lateral shoulder joint injury, excessive abduction of the upper limbs and shoulder dislocation during tussling and other situations, should be carefully considered. The location of the rotator cuff tear was analyzed according to the form and force of trauma. Among all the inspections, the signs of injury shown by MRI, bone contusion, tendon and soft tissue contusion and edema constitute the most valuable judgment basis. Studies have shown that the greater the force of acute trauma is, the more obvious the sign of accompanying injury on MRI [25]. In addition, compared with lesions alone, RCTs caused by acute trauma generally occur at the direct force site of the rotator cuff. Second, the factors of own disease should be analyzed, especially the cases that lack signs of accompanying injury and trauma, which may lead to RCTs. The relevant indicators of degeneration, CSA, AHD, AGA, FI, OG and other factors were analyzed by X-ray or CT and MRI to determine the

degree of disease involvement. Finally, the analysis results of the first and second steps are combined to form a clear appraisal opinion. The opinion should specify what specific factors caused RCT, providing an objective basis for the court's decision.

Conclusion

The relationship between acute trauma and one's own disease, which is related to the notarization of court decisions and the conviction of the parties and the compensation of the victims, is accurate. In summary, first, the magnitude and form of acute trauma combined with signs of accompanying injury on MRI were used to analyze whether acute trauma leads to RCT. An analysis of the factors of own disease, especially in patients who lack signs of accompanying injury and acute trauma, may result in RCTs, including AHD, FI, OG and other factors. X- or CT and MRI can be used to determine the degree of disease. Finally, the above two parts form clear appraisal results for court judgment (Figure 6).



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